Back to Basics – Stainless Steel

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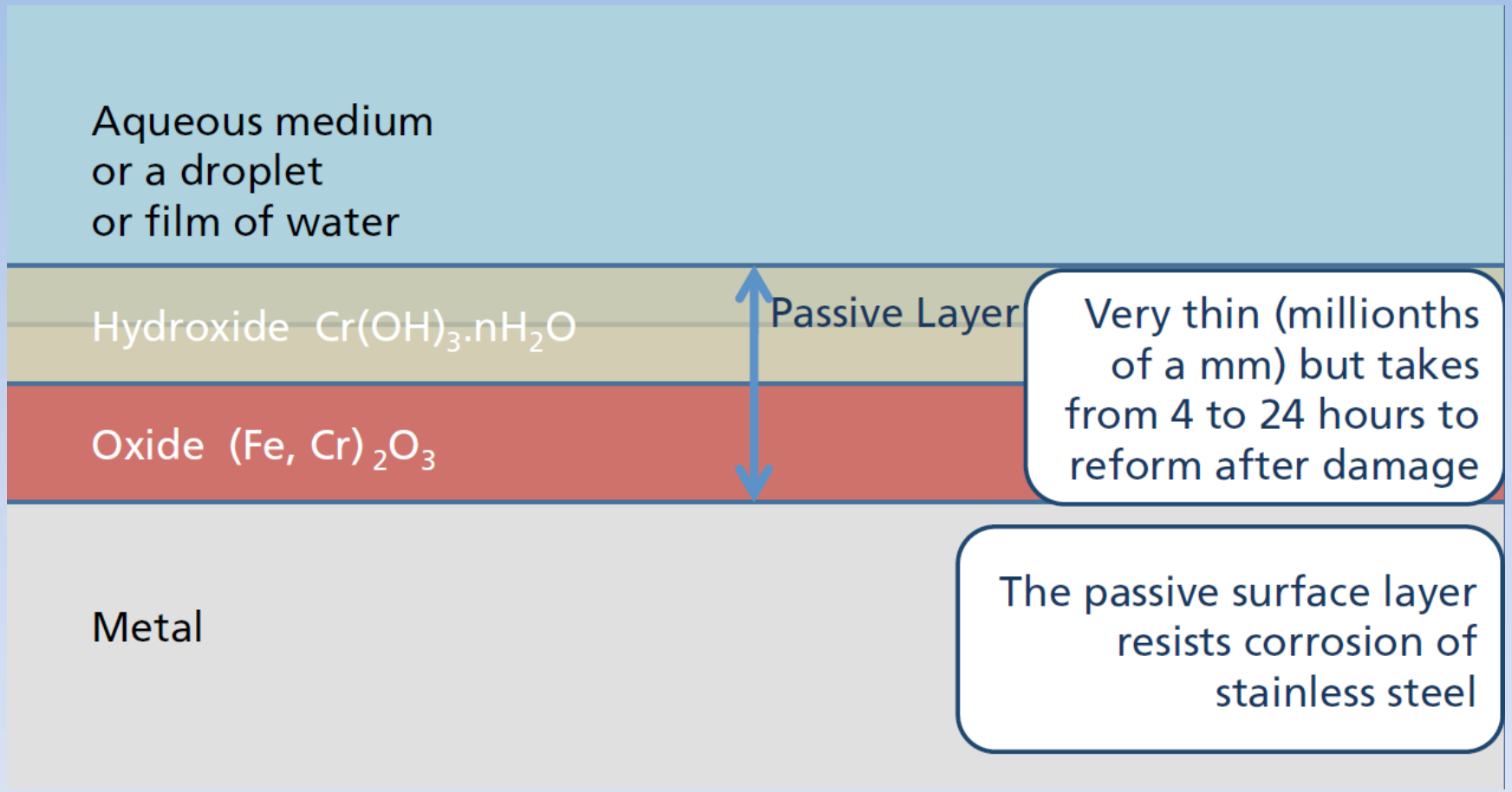
What is Stainless Steel?

- Group of steels which have a minimum of 10.5% Cr
- Creates a Chromium Oxide surface layer
- Passive to a wide range of corrosive substances
- But not entirely corrosion resistant!

Passive Surface Film

- Extremely thin – a few millionths of a millimetre
- Self Repairing
- Starts in milliseconds and grows to its old thickness between 4 and 24 hours
- **What could go wrong?**
  - Steel smears or chlorides on the surface
  - Manganese sulphide precipitates exposed on the surface
  - Passive layer not adequately formed
  - *Wrong grade for the environment with not enough corrosion resistance*

The Passive Film

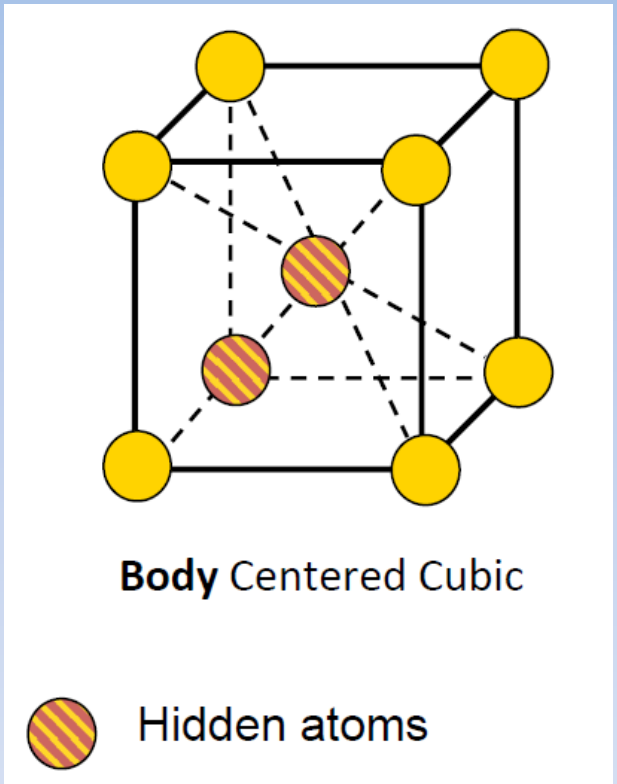


Families & Grades of SS

Name	Description	
Ferritic	Fe - Cr	(4XX Series)
Austenitic	Fe – Cr – Ni 304 Grade 316 Grade Fe – Cr – Mn	(3XX Series) 18%Cr, 8% Ni 18% Cr, 12% Ni (2XX Series)
Duplex	Fe – Cr – Ni 2205	(XXYY - %CR %Ni) 22% Cr, 5% Ni
Martensitic	Ferritic with High C	(4XX Series)
Precipitation Hardening	Stainless steels with structures strengthened bu the formation of precipitates due to the alloys used	

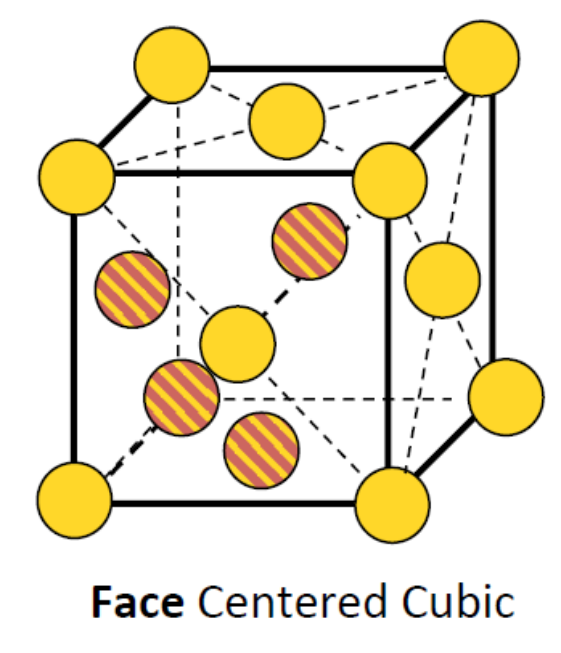
Addition of Nickel

Ferritic SS



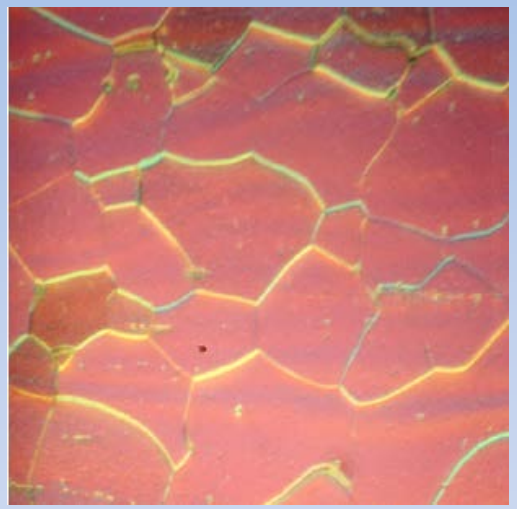
Add Nickel

Austenitic SS

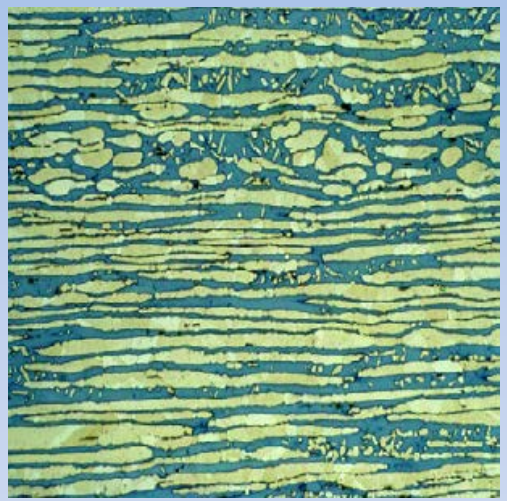


Formable, weldable, tough

Addition of Nickel



0% Nickel
Ferritic Stainless Steel



5% Nickel
Duplex Stainless Steel

>8% Nickel
Austenitic Stainless Steel

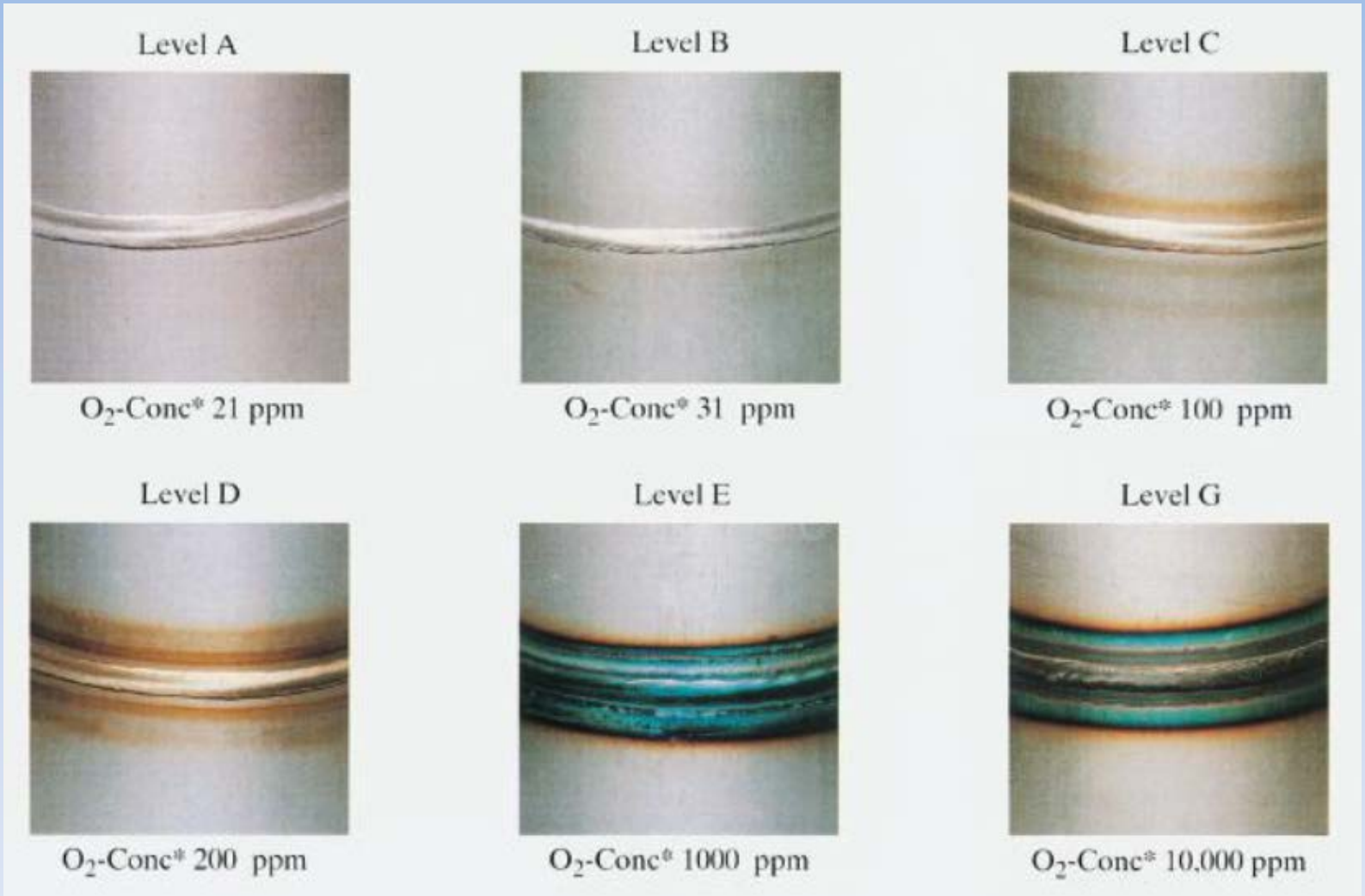
Corrosion Resistance of SS

- Reliant upon the Chromium Oxide film
- Damaged by:
  - Welding
  - Forming/scratching
  - Chemical/biological attack depleting the chromium in the layer
  - Embedded contaminants (e.g. iron, sulphides)
- Necessary to reform the passive layer

Welding – Heat Tint

- With exposure to O_2 at high temperatures, a thin Cr_2O_3 layer forms – Straw Tinted
- Cr depleted layer forms under the heat tint
- With additional exposure and O_2 pick up, this layer becomes unstable – dark blue/black layer is formed
- Further depletion of Cr and an increase in Fe content at the surface.

Welding – Heat Tint



Welding

- During Welding – Exclude O_2 by
  - Inert shielding gas – Argon or mix with N_2 to promote Austenising/Corrosion resistance
  - Purge with Inert gas
- After Welding – Treat the surface to
  - Remove contaminants
  - Promote formation of the passive film

Post Weld Treatment - Pickling

- Removal of surface contaminants:
  - Scale
  - Embedded Ferrite
  - Depleted Surface layer
  - Surface contaminants, e.g. grease, marking pen marks, anti spatter etc
- Restores corrosion resistance through auto passivation
- Full corrosion resistance by a passivation treatment subsequent to pickling

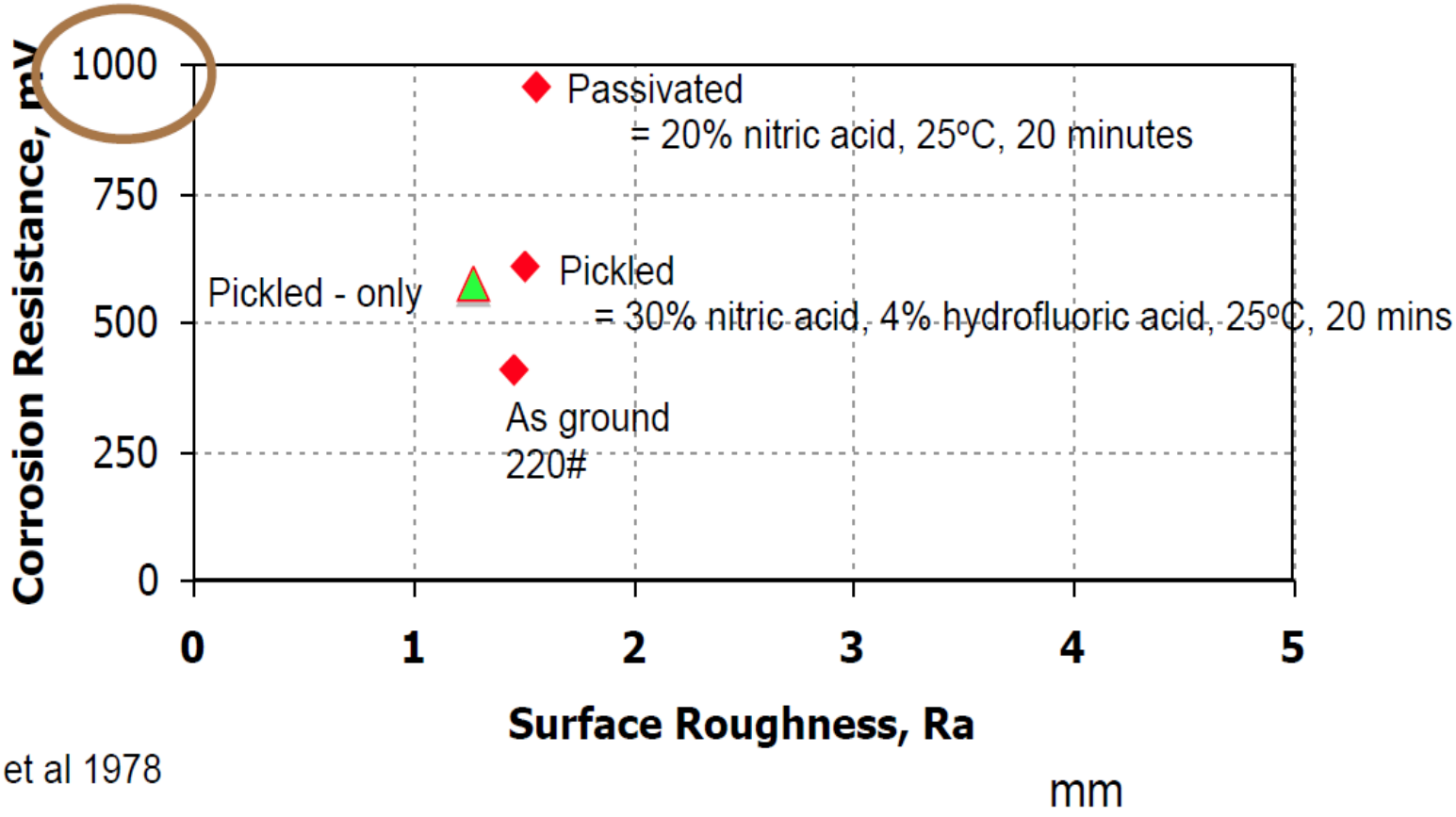
Pickling

- Options:
  - Mechanical
    - Blasting, grinding, wire brushing, polishing, etc
    - Hide the oxide layer, but don't remove it, or the low chromium layer
    - Risk of contamination by poor operation
  - Chemical
    - hydrofluoric (HF) and nitric (HNO_3) pastes, gels, dips, sprays, etc
    - Chemically removes contaminants
    - Leaves higher surface Cr and less Fe

Passivation

- After pickling, the surface is still active.
- The passive film restoration is dependent on the availability of oxygen for its formation, and also subject to inhibition by atmospheric pollution, airborne chlorides, etc
- Chemical passivation rapidly restores the passive layer.
- Historically passivation treatment involved the use of nitric acid
- Citric acid based products do not strip the nickel or chromium from the surface, the rinse water can normally be put directly to drain

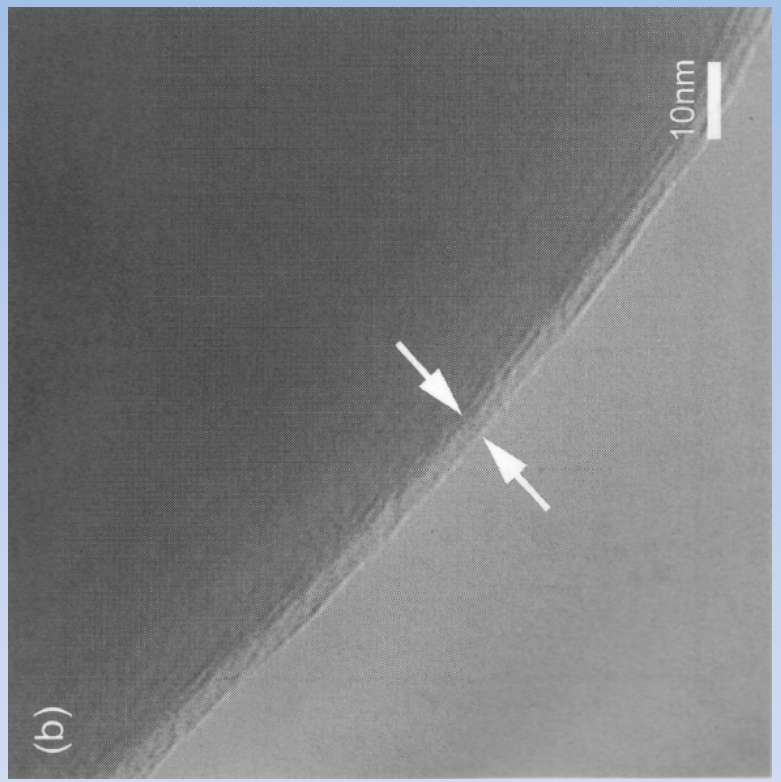
Pickled & Passivated



Ericsson et al 1978

Passive Layer

Before Nitric Acid Treatment



After Nitric Acid Treatment

The oxidising treatment thickens the protective film

Acknowledgement

- ASSDA
- Avesta
- FutureSafe Solutions

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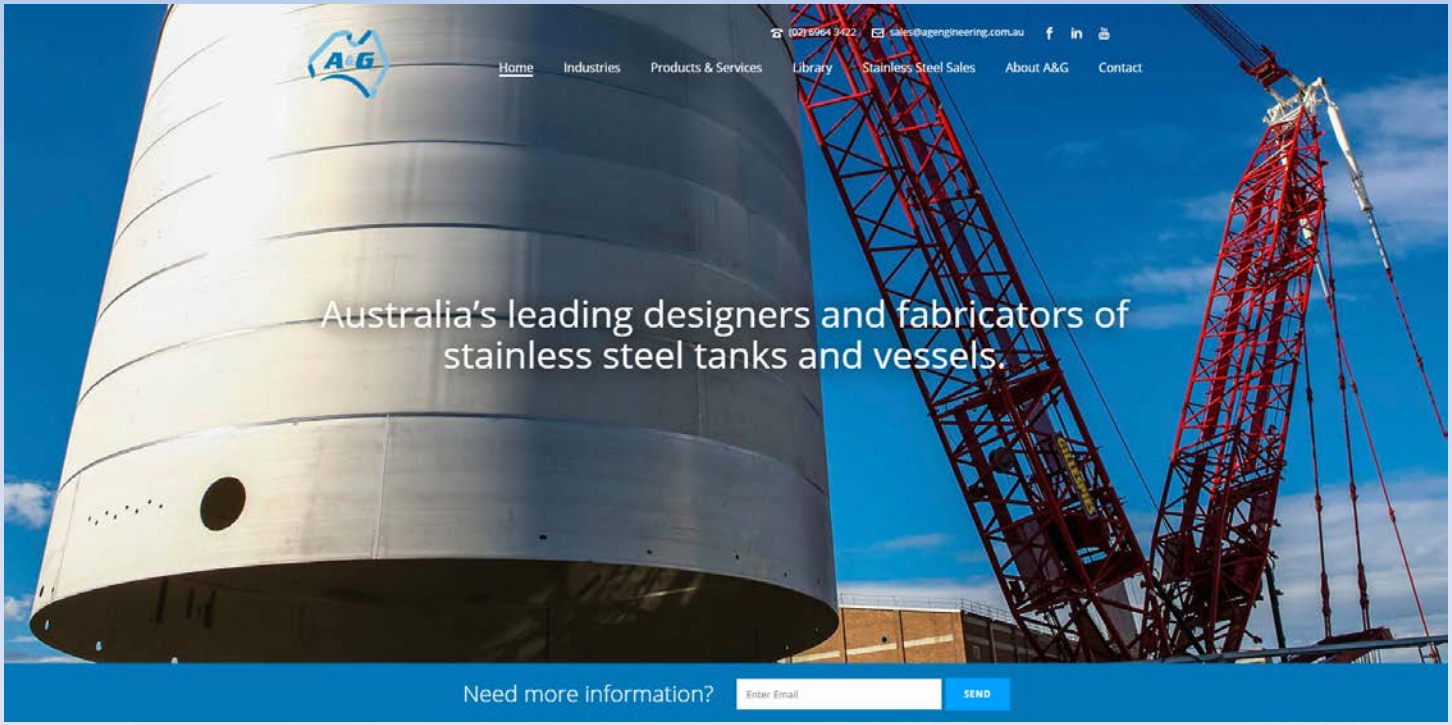
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